

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :  
F16L 55/04

A1

(11) International Publication Number: WO 97/46823

(43) International Publication Date: 11 December 1997 (11.12.97)

(21) International Application Number: PCT/US97/09677

(22) International Filing Date: 4 June 1997 (04.06.97)

(30) Priority Data:  
08/660,676 5 June 1996 (05.06.96) US

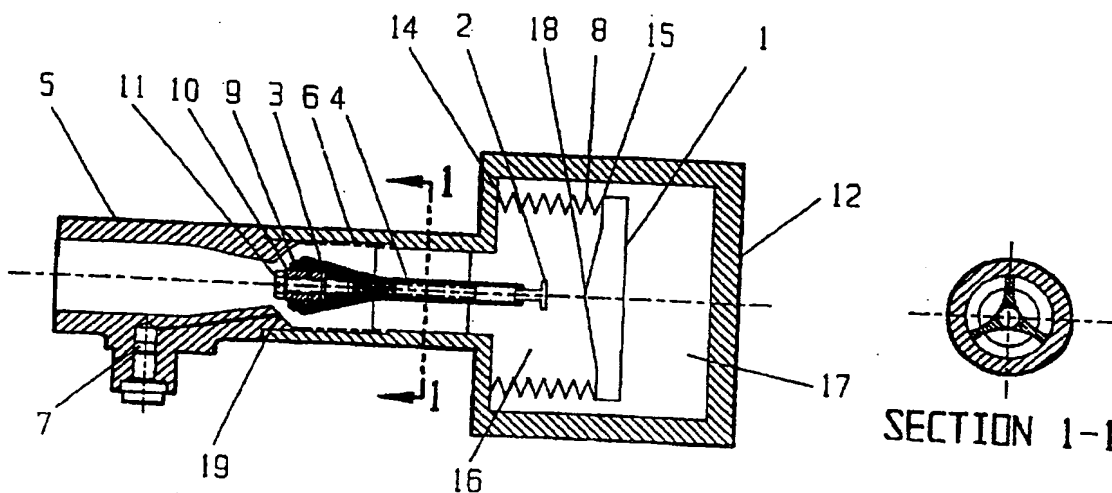
(71)(72) Applicant and Inventor: LORAN, Haim [US/US]; 250  
Carlton Road, Millington, NJ 07946 (US).

(74) Agent: CIPOLLONE, Anthony, D.; One Essex Street, Hacken-  
sack, NJ 07601 (US).

(81) Designated States: JP, European patent (AT, BE, CH, DE, DK,  
ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published  
With international search report.

(54) Title: A NOVEL ACCUMULATOR



(57) Abstract-

An improved hydraulic accumulator is introduced wherein a valve mechanism (3) is used to seal a hydraulic fluid before the pressure charged piston (1) reaches the end of the accumulator to minimize the loss of compressed gas by eliminating the pressure differential when the piston (1) is fully extended, thereby prolonging the fatigue life of the accumulator vessel. Reduction of the pressure loading on the vessel will also prolong the life of the piston seals and metal bellows (8) effectively extending the accumulator life and effectively allowing design for weight reduction and preservation of the integrity of the complete hydraulic or pneumatic system.

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

## A NOVEL ACCUMULATOR

Background & Field of the Invention

## 1. Field of the Invention

When hydraulic accumulators discharge their working fluid, the dynamic gas/fluid separating device, consisting of a bellows or piston, is placed in a condition of high steady state stress. This stress is due to the force created by the gas pre-charge pressure present or on the side of the separator and the actual lower-working pressure on the expelled fluid side. Further, high point contact loads may exist where the separator mechanically stops on the accumulator vessel structure.

The foregoing conditions must be considered by the designer, especially in high performance driven applications where weight of the unit and operating life are major factors. One factor must be compromised with the other.

## 2. Description of Prior Art

a) U.S. Patent No. 2,745,357 introduces an aircraft hydraulic system with an improved pressure type reservoir.

b) U.S. Patent No. 4,601,369 describes a pressure vessel.

c) U.S. Patent No. 4,852,615 teaches a hydropneumatic accumulator with two chambers.

d) U.S. Patent No. 4,959,958 shows a hydraulic

1 g) U.S. Patent No. 5,036,661 shows a regulated level  
2 accumulator for liquid under high pressure.  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34

1

2

3

4

Summary Of The Invention

5 A valve mechanism is introduced in conjunction with an  
6 accumulator piston and vessel, the piston acting as a  
7 separator to separate liquid from gas components. The  
8 valve mechanism is so designed as to sense the relative  
9 position of the piston.

10 The valve mechanism will limit the expelled fluid volume of  
11 the accumulator to obtain pressure equilibrium across the  
12 piston (separator). This action of the valve mechanism  
13 reduces the pressure differential and forces across the  
14 piston causing the high, steady stress levels of the  
15 piston, eliminating the high contact loads on the static  
16 housing.

17 The valve mechanism will limit the expelled fluid near the  
18 time of complete discharge such that the fluid pressure  
19 will not be below the gas pre-charge pressure. This  
20 mechanism may be used in a static vessel, dynamic piston  
21 (separator) or as a separate system interfacing with the  
22 accumulator.

23 Localized high stressed concentrations in either the fluid  
24 separator or the surrounding shell resulting from the  
25 piston (separator) being bottomed on the hydraulic end of  
26 the shell causes fatigue and a short life span for the  
27 shell.

28 Accumulators are used for two separate functions in the  
29 standard hydraulic system. The first is to store energy in  
30 the form of compressed gas and hydraulic fluid. The second  
31 is to absorb pressure spikes which occur when a component  
32 in the hydraulic system actuates or performs work. Both of  
33 these applications require the use of a compressible fluid  
34 (gas, i.e. nitrogen, helium, air etc.) on one side of a

1 separator and a non-compressible fluid (hydraulic oil) on  
2 the other side. When the hydraulic system pressure drops  
3 below the pre-charged pressure of the gas side, the  
4 separator will move in the direction of the hydraulic side,  
5 displacing stored hydraulic fluid into the system as  
6 required. When the hydraulic system is shut down, the  
7 separator goes to the full stroke stopped position and you  
8 are left with the full pre-charge pressure being applied to  
9 the area of the separator creating a force which acts on  
10 the separator and thereby inducing a stress in this member.  
11 When fully bottomed, this load is also applied to through  
12 the stopping mechanism which in turn creates a localized  
13 high stress area in the shell.

14 With both of the above, the noted stresses can be addressed  
15 by material selection and/or material thickness and  
16 physical geometry. Typically, both of these approaches can  
17 add considerable weight to the final design solution and,  
18 in many cases, reduce the entire overall performance, as a  
19 result of the weight penalty, of the entire operating  
20 system.

21 The present approach is to capture enough fluid in the  
22 hydraulic side of the accumulator to keep the separator  
23 from just short of its bottoming position, thereby  
24 equalizing the pressure on both sides of the separator  
25 which will, in turn, reduce the stress levels attributable  
26 to the pressure loading of the separator. This will also  
27 prevent the separator from physically bottoming on the  
28 hydraulic shell, resulting in a uniformly distributed  
29 pressure loading of the hydraulic shell.

30  
31  
32

1  
2  
3                    BRIEF DESCRIPTION OF THE DRAWINGS

4            Figure 1.            Cross section of the accumulator using  
5            bellows as a separator of gas & fluid chambers.

6            Figure 2.            Cross section of alternative accumulator  
7            design using piston as a separator of gas & fluid chambers  
8            showing poppet in sealed position.

9            Figure 3.            Cross section of alternative accumulator  
10           design using piston as a separator of gas & fluid chambers  
11           showing poppet in the open position.

12           Figure 4.            Cross section detail of tail end of poppet  
13           in the open position.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32

1  
2  
3 DETAILED DESCRIPTION OF THE PREFERRED  
4 EMBODIMENT OF THE INVENTION  
5

6 The first embodiment of the invention is shown in Figure 1  
7 and Figure 4 and will now be described.

8 This embodiment is the preferred embodiment of the  
9 invention. It is important to note that the poppet  
10 described in Figures 1, 2, 3, 4, 6, 9, 10 and 11 is the  
11 point of the invention. The addition of this poppet to the  
12 accumulator design permits control of the expelled fluid  
13 such that the fluid side pressure will not be below the gas  
14 pre-charge pressure. This valve sealing mechanism will  
15 allow the piston to travel to a position of pressure  
16 equilibrium and will prevent contact loads from being  
17 transferred to the vessel permitting the sealing prior to  
18 the piston achieving the fully stroked position,  
19 eliminating contact stress with the vessel.

20 Referring to Figure 1, as the pressure in the hydraulic  
21 system exceeds the gas pressure, the return spring (6) will  
22 apply force to the valve mechanism to return it to an open  
23 position. The return spring (6) is attached to poppet (3)  
24 which when opened allows hydraulic flow into the liquid  
25 chamber (16) compressing the gas in the gas chamber (17) of  
26 the accumulator chamber (12). This hydraulic flow expands  
27 the bellows (8) moving the protruding center (18) of the  
28 rear wall of the piston (1) away from the contact pin (2)  
29 of the poppet (3) compressing the gas in the gas chamber  
30 (17).  
31  
32  
33



1 Referring to Figure 2, as the piston (1) strokes to a  
2 predetermined position or gas volume in the gas chamber  
3 (17) its protruding center (18) contacts the contact pin  
4 (2) which then compresses the contact pin spring (4)  
5 forcing the poppet (3) to seal the fluid chamber with the  
6 poppet seal (9) held by seal retainer (10) with the seal  
7 retainer screw (11) to the poppet (3) seals the fluid  
8 chamber by coming into contact with the shoulders (19) of  
9 the valve seat (5). On the lower portion of the valve seat  
10 (5) is a pressure test port (7) which is used to check the  
11 hydraulic pressure of the system and whether the poppet  
12 seal (9) is properly sealed. At full discharge of the  
13 accumulator, the hydraulic pressure between the poppet seal  
14 (9) and the piston (1) in the liquid chamber (16) equals  
15 the pressure in the gas chamber (17).

16 An alternative embodiment of the invention is demonstrated  
17 in Figure 2 and Figure 3. Therein, bellows are replaced by  
18 the piston (1). The piston (1) acts as a separator between  
19 the liquid chamber (16) and the gas chamber (17) with the  
20 piston (1) flush with the interior walls of the accumulator  
21 housing (12), sealed by "O" ring (13). The principles and  
22 operation of the accumulator so designed is the same with  
23 the exception of the replacement for the bellows (8).

24 Figure 2 shows the poppet seal, in the closed position,  
25 with the (9) seal and seal retainer (10) resting on the  
26 shoulders (19) of the seal valve to stop the fluid flow to  
27 the liquid chamber (16) when the pressure in the liquid  
28 chamber (16) is equal to the pressure in the gas chamber  
29 (17).

30 Figure 4 is a cut away portion of the poppet (3) in its  
31 open position to allow fluid to flow into the liquid  
32 chamber (16) wherein the return spring (6) is acting in

1        opposition to compression spring (4) pushing out the  
2        contact pin (2) to push out piston (1) to compress the gas  
3        in the gas chamber (17).

4        Also shown are the seal retainer (10) and seal (9) on the  
5        poppet (3) held together by seal retainer screw (11) away  
6        and from the shoulder away and from the shoulders (19) of  
7        the seat valve (5) in the open position.

1  
2  
3       DETAILED ADVANTAGE & UNIQUE POINTS OF THE INVENTION

4       The point of present invention is the introduction of the  
5       poppet valve design to seal the fluid chamber prior to the  
6       piston reaching the fully stroked position. This unique  
7       design prevents the piston from being subjected to the full  
8       pre-charge load during cycling.

9       An additional benefit of this valve mechanism is the  
10      establishment of an equilibrium position with the spring  
11      loaded poppet valve design providing an integral pressure  
12      relief feature due to pressure changes associated with  
13      temperature changes in the system.

14      The foregoing features introduced by this unique poppet  
15      valve system decrease fatigue and wear and tear on the  
16      system, thereby increasing the longevity of the  
17      accumulator.  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

WHAT IS CLAIMED IS:

1. An accumulator comprising:
  - a) a hollow housing;
  - b) a bellows located inside the housing, said bellows including a bellows body having a first end and a second end, said first end being secured to the housing and second end being allowed to move in an axial direction of the housing;
  - c) a bellows attachment to a piston for closing the second end of the bellows body;
  - d) a liquid chamber defined by the inner face of the bellows and filled with a liquid;
  - e) a gas chamber defined by the outer face of the bellows body and said piston and charged with a compressed gas;
  - f) a tube seat having a liquid flow port communicating with the liquid chamber and allowing liquid in the liquid chamber to pass when the bellows is compressed or expanded and a first set of shoulders at forward end of said tube seat;
  - g) a self-seal mechanism comprising a shaft with an arrow-shaped poppet having an outer tail end in an axial position opposite a contact pin directly opposite said rear protruding center of said piston which has a second set of shoulders which comes into contact with said first set of shoulders on said forward end of tube seat when said pin is compressed when gas in said chamber forces said piston to make contact with said contact pin;
  - h) said contact pin in the said shaft of said arrow-shaped poppet connected to a compressible inner spring to force an

outer spring attached to said outer tail end of said poppet in an axial position opposite said contact pin to be compressed when said piston is in contact with said contact pin pushing said outer tail end of poppet to slat on said tube seat with a seal retainer and seal on said tail end of said poppet to cause liquid flow to stop flowing into liquid chamber;

i) said self-seal mechanism for closing the said liquid flow port when the pressure changes of the compressed gas in the gas chamber forces the bellows to be deformed in its axial direction to a pre-determined extent, part of the liquid in the liquid chamber being confined to a region inside the bellows when the said self-seal mechanism is closed by the action of the said piston coming into contact with said contact pin of said poppet;

j) said second set of shoulders of said shaft having a seal retainer and seal which comes into contact with and sits on said first set of shoulders of said tube seat to prevent liquid flow into the now sealed liquid chamber;

k) said self-seal mechanism also comprising outer spring and will compress in an axial direction opposite said inner spring which will compress said inner spring allowing hydraulic flow pressure from the liquid to open said seal and permit bellows to expand pushing the piston forward to compress gas in said gas chamber.

2. An accumulator comprising:

a) a hollow housing;

b) a piston inside said housing; said piston being flush with interior wall of said housing sealed by an "O" ring;

c) said piston separating a gas chamber from a liquid chamber;

d) said liquid chamber defined by interior wall of said

housing and rear side of said piston;

e) said gas chamber defined by the interior wall of said housing and forward side of said piston and charged with compressed gas;

f) said piston having a protruding center portion on its rear wall in liquid chamber;

g) a tube seat having a liquid flow port communicating with the liquid chamber and allowing liquid in the liquid chamber, said tube seat having a first set of shoulders at a forward end of said tube seat;

h) a self-seal mechanism comprising a shaft with an arrow-shaped poppet having an outer tail end in an axial position opposite a contact pin directly opposite said rear protruding center of said piston which has a second set of shoulder which come into contact with said first set of shoulders on said forward end of the tube seat when said pin is compressed when gas in said chamber forces said piston to make contact with said contact pin;

i) said contact pin in the shaft of said arrow-shaped poppet is connected to a compressible inner spring to force an outer spring attached to said outer tail end of said poppet in an axial position opposite said contact pin to be compressed when said piston is in contact with said contact pin pushing said outer tail end of poppet to seat on said tube seat with a seal retainer and seal on said tail end of said poppet to cause liquid flow to stop flowing into said liquid chamber;

j) said self-seal mechanism for closing the said liquid flow port when the pressure changes of the compressed gas in the gas chamber forces the piston to move in the axial direction to a predetermined extent, part of the liquid in the liquid chamber being confined to a region inside the

accumulator when the self-sealed mechanism is closed by the action of the said piston coming into contact with said contact pin of said poppet;

k) said second set of shoulders of said shaft having a seal retainer and seal which comes into contact with and sits on said first set of shoulders of said tube seat to prevent liquid flow into the now sealed liquid chamber;

l) said self-seal mechanism also comprising outer spring which will compress in an axial direction opposite said inner spring and will compress said inner spring allowing hydraulic flow pressure from the liquid to open said seal and permit the liquid chamber to be pressurized pushing the said piston forward to compress gas in said gas chamber.

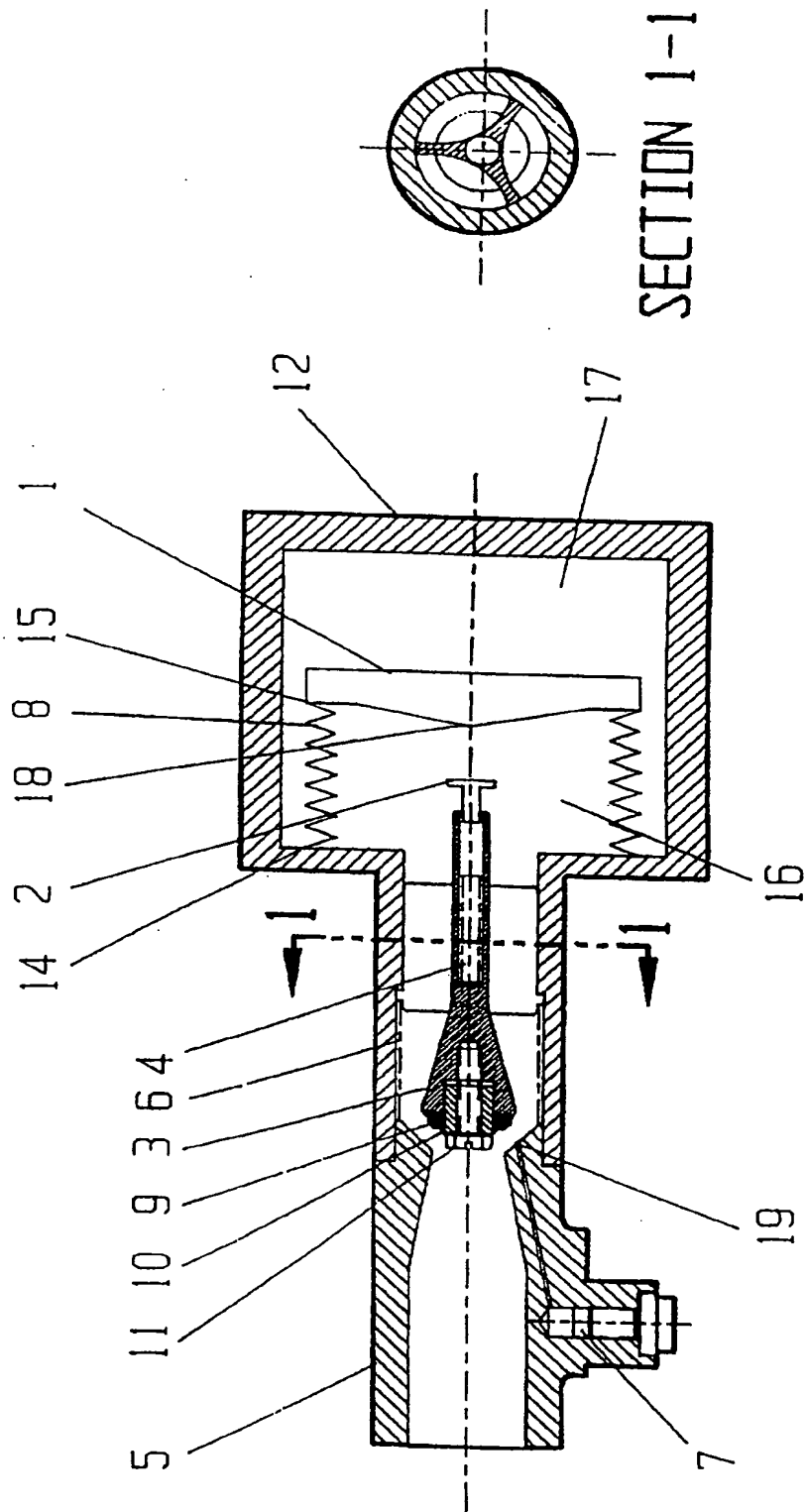


FIG. 1



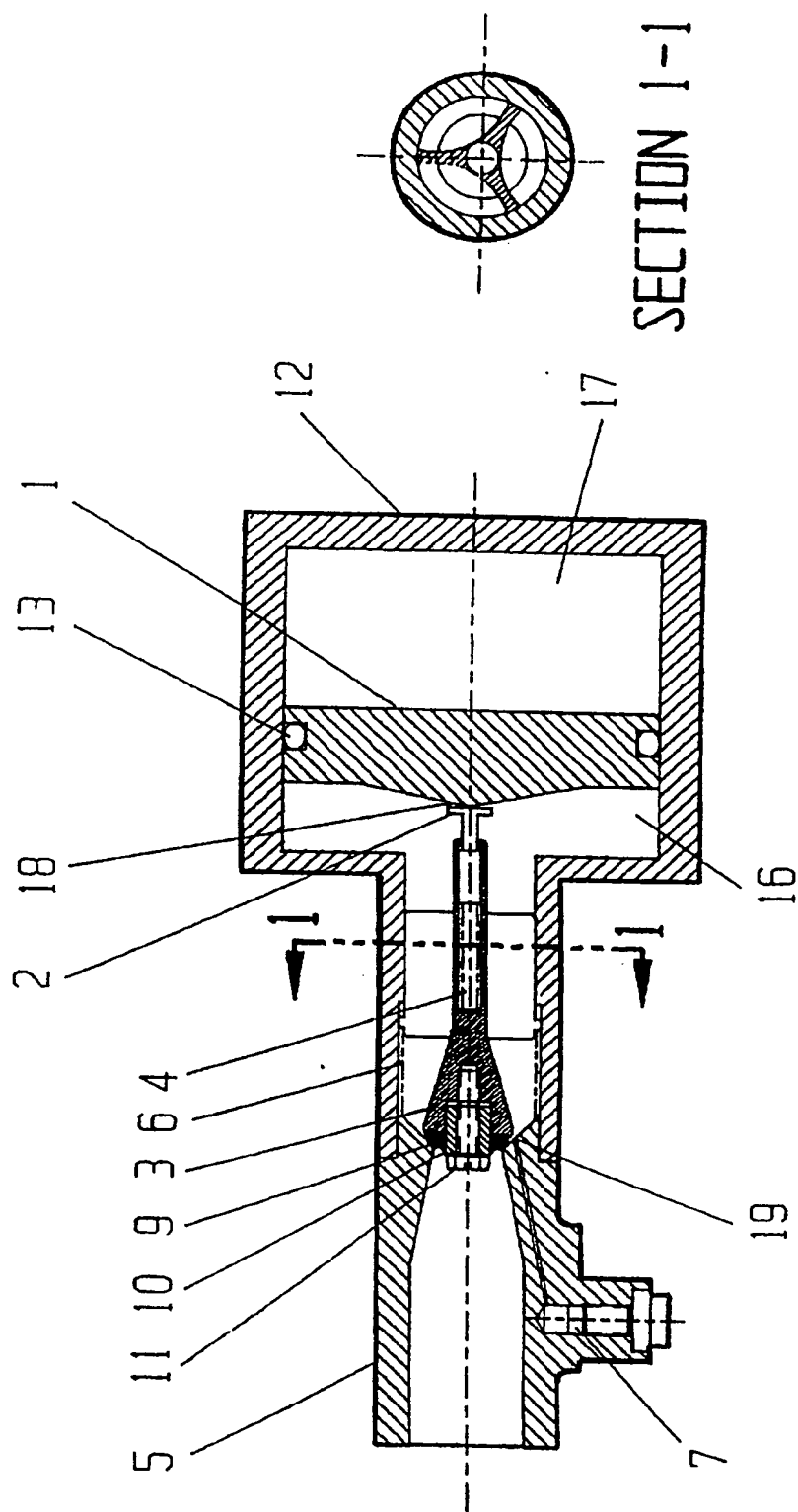


FIG. 2

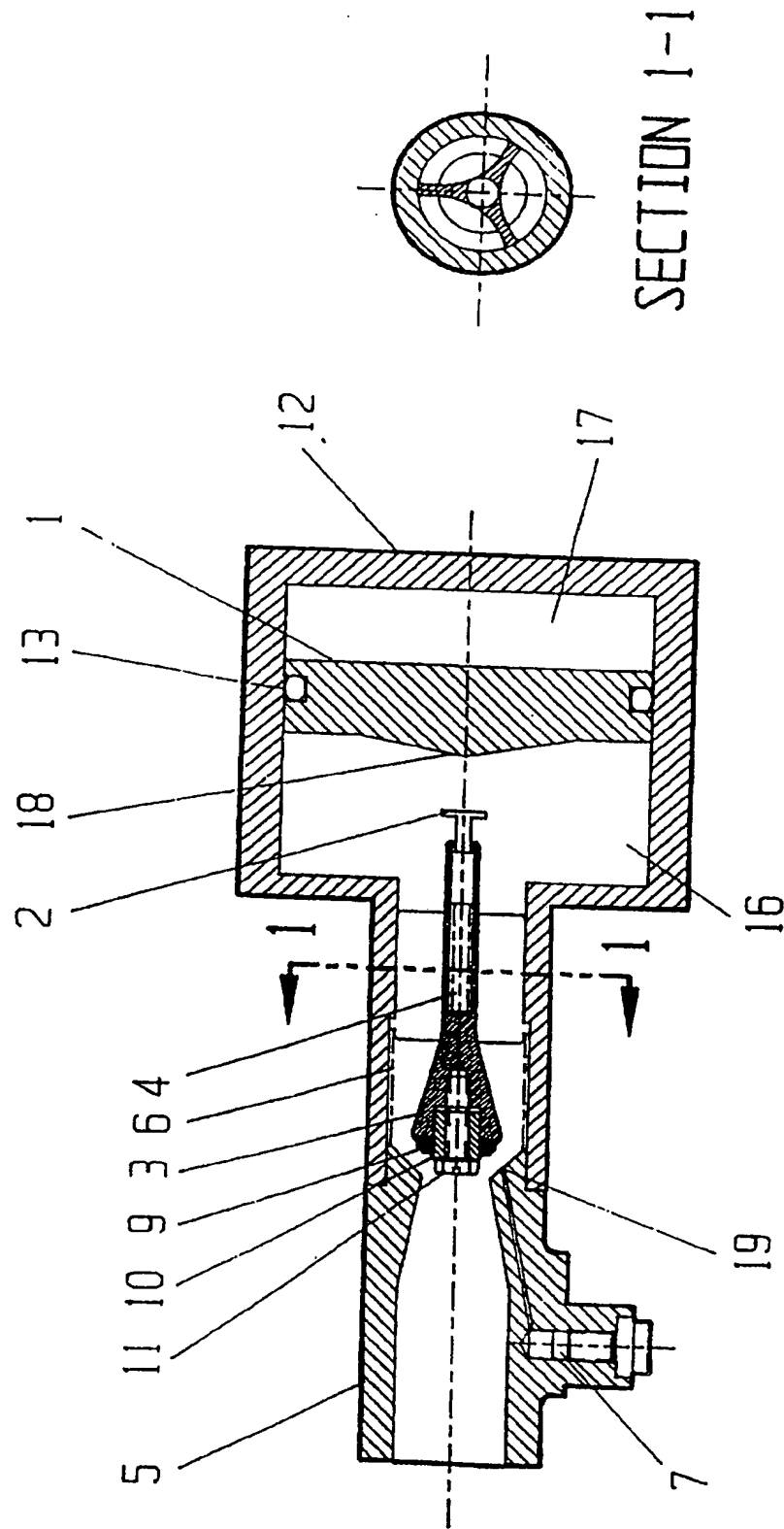


FIG. 3

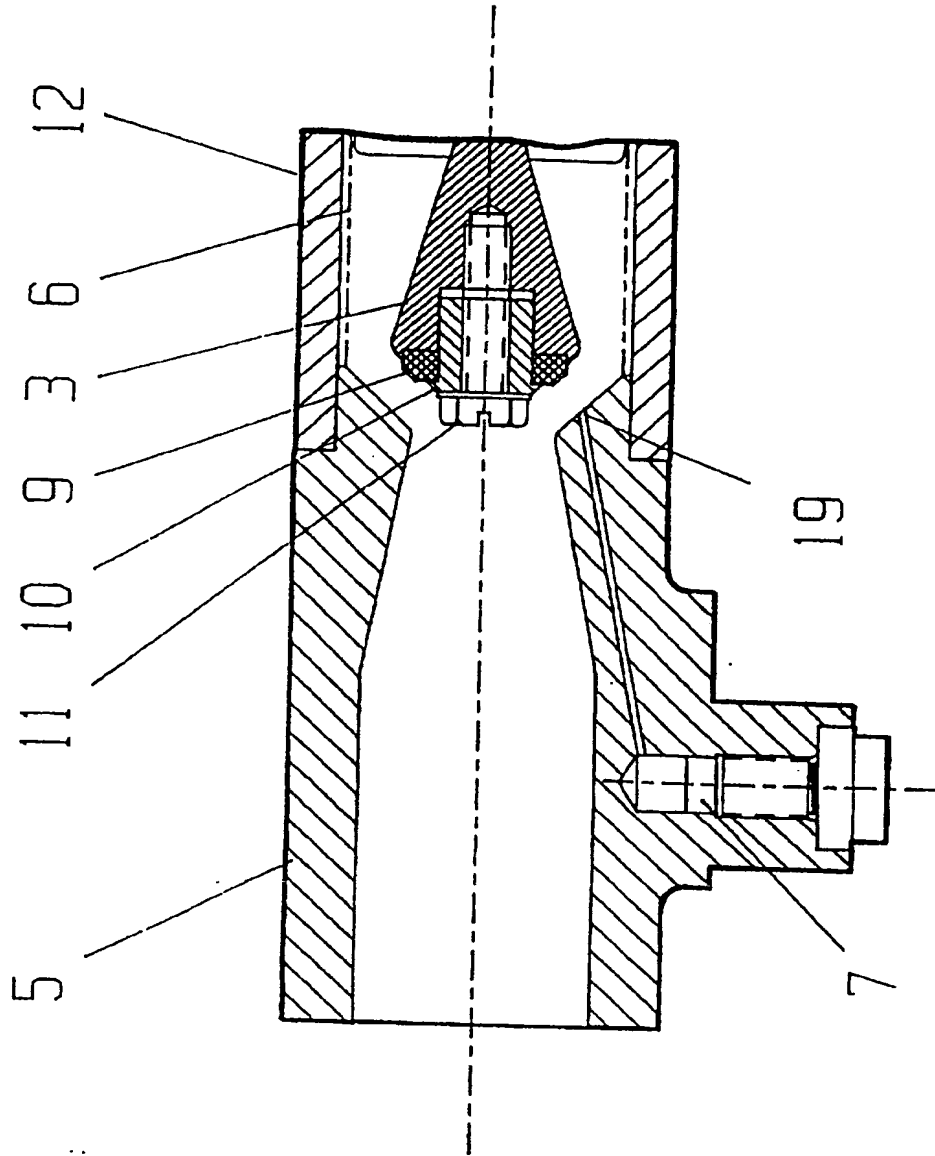


FIG. 4

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US97/09677

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : F16L 55/04

US CL : 138/31

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 138/31, 30, 26; 220/721

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,336,948 A (LUCIEN) 22 August 1967, entire document.	1 and 2
A	US 4,461,322 A (MILLS) 24 July 1984, entire document.	1 and 2
A	US 4,691,739 A (GOODEN) 08 September 1987, entire document.	1 and 2
A	US 4,997,009 A (NIKURA et al) 05 March 1991, entire document.	1 and 2
A	US 5,388,899 A (VOLZ et al) 14 February 1995, entire document.	1 and 2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"B" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Z" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

18 JULY 1997

Date of mailing of the international search report

12 AUG 1997

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231Authorized officer *P. Hulley for*  
PATRICK F. BRINSON

Facsimile No. (703) 308-7766

Telephone No. (703) 308-0111

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☐ BLACK BORDERS

☒ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES

☒ FADED TEXT OR DRAWING

☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING

☐ SKEWED/SLANTED IMAGES

☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS

☐ GRAY SCALE DOCUMENTS

☒ LINES OR MARKS ON ORIGINAL DOCUMENT

☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY

☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**